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RECOVERY POTENTIAL ASSESSMENT FOR SPRING CISCO (*COREGONUS* SP.)

Spring cisco
(photo: Michel Hénault, MNRF)

Figure 1: Spring cisco distribution range: Lac des Écorces (MNRF)

Context

In April 2009, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the spring cisco (Coregonus sp.) as Endangered. The rationale for the designation is due to the species' occurrence in only one small lake in south-western Quebec and by the decline of its abundance index. This situation could be related to a number of factors including habitat degradation and loss resulting from urban and agricultural development, the introduction of competing and predator species and climate change.

A species recovery potential assessment (RPA) process was therefore set up by DFO Science in order to provide the information and scientific advice required to meet the various requirements of the Species at Risk Act (SARA), such as deciding whether or not to add the spring cisco to the list, the authorization to carry out certain activities as well as the development of recovery strategies.

This advice describes the spring cisco situation and identifies recovery targets for the species. Threats to habitat and species as well as measures to mitigate them are also listed. This advice offers a perspective on the recovery potential for spring cisco.

SUMMARY

- In Canada, the only known spring cisco population has been observed at Lac des Écorces (46°31'48" N, 75°25'03" W) in the Laurentians (Quebec). Its survival and recovery depend on its sustained production within this habitat.

- Reproductive isolation of cisco spring, compared to lake herring (*C. artedi*), and the morphological differences observed support its genetic specificity.

- Despite the uncertainty related to the data, the trend over the last fifteen years, between 1994 and 2008, reflect a significant decline in the population.

- A recovery target representing 40% of the average abundance indices (number of catches per unit effort) before the decline during 1990s, or a target of around 5 individuals per hour per net, is proposed.

- The absence of key parameter estimates of population dynamics prevents making projections on the development of the spring cisco population.

- Lac des Écorces, as a unique habitat for spring cisco, is essential to the survival and recovery of the species. Knowledge about the habitat use by different life stages is still incomplete but nothing indicates that some parts of the lake are not used. Damage or loss of any and all parts should therefore be avoided.

- The introduction of competing and predatory species, especially rainbow smelt, caused changes in the fish community. Predation by rainbow smelt on spring cisco larvae in the deeper parts of Lac des Écorces, raises some concern. Controlling the rainbow smelt population could contribute to the recovery of spring cisco.

- Lac des Écorces has been subject to many disturbances due to urban and agricultural development over the last 50 years, which has significantly deteriorated the lake and could have caused loss of habitat. Although it is difficult to quantify the impact, salmonid sensitivity to the degradation of the biophysical environment is well known. Measures to mitigate threats to the habitat could contribute to the survival and recovery of the species.

- According to current available knowledge and information, the recovery of spring cisco remains uncertain, but possible.

BACKGROUND

Rationale for Assessment

Spring cisco was designated "Endangered" as a result of a reassessment in April 2009 by the COSEWIC. This species, listed in 1992 under Schedule 3 of the *Species at Risk Act* (SARA), was considered Special Concern. Species that have been designated Endangered by the COSEWIC since the introduction of the SARA should be added to Schedule 1 by means of a regulatory change. If spring cisco is added to this schedule, it may benefit from protection measures under the SARA. Many of these measures require information on the species' current situation and trajectory, on the recovery targets, on the threats to its survival as well as on ways that can promote recovery. The recovery potential assessment can help link scientific information to further actions. This scientific advice is also aimed at contributing to the decision-making in terms of whether or not to add the species to Schedule 1 of the SARA.

Species Biology and Ecology

Similar to lake herring (*C. artedi*) that spawn in the fall and whose distribution in Canada is more extensive, spring cisco (*Coregonus* sp.), which spawn in spring, has a distribution limited to only one small lake. Reproductive isolation for spring cisco, compared to lake herring, and the morphological differences observed, support its genetic specificity.

Spring cisco reach sexual maturity at 3 years of age, and few individuals survive beyond age 8. The average age is 5 years. The oldest specimen ever caught was a female of 11 years. The maturation of oocytes begins in the fall and continues throughout the winter, reaching its peak between mid-May and early June, just before spawning. During this period, spawners gather in deep pools in the lake. Female fecundity varies depending on size and ranges between 29,400 and 74,900 eggs/kg for females measuring between 220 and 265 mm. Hatching begins in late July and continues during the month of August. Therefore, it appears that cisco larvae float to the surface to fill their swim bladder of atmospheric oxygen, and then they begin to feed.

The information on the spring cisco diet is inferred from the literature on lake herring. Pelagic cisco larvae are planktivorous cisco and feed almost exclusively on copepods and cladocerans. Adults in search of food remain in the hypolimnion during the summer. They feed on plankton, but have a varied diet consisting of insects, eggs, small fish and crustaceans. Spring cisco play an important role in the food chain of Lac des Écorces, being the prey of several species, such as northern pike, walleye, smallmouth bass, yellow perch and rainbow smelt.

ASSESSMENT

Current Situation

In Canada, the only known spring cisco population has been observed at Lac des Écorces (46°31'48" N, 75°25'03" W) in the Laurentians (Quebec). The species' distribution range corresponds to the size of the lake, or 6.58 km^2.

It is difficult to draw conclusions on the abundance of spring cisco as the available data on the species remains limited. The trend over the last fifteen years, between 1994 and 2008, however, reflects a significant decline in the population. Based on experimental fisheries carried out since 1981, the number of spring cisco catches per unit effort (CPUE) shows a downward trend since the 1990s. The number of fish caught has also declined during this period, while the effort has increased, particularly in recent years. The average size of fish caught also presents a slight decrease.

Recovery Target and Trajectory

Abundance Index

To establish a target for restoring the spring cisco population of Lac des Écorces, we do not have estimates of current and historical abundance, but only indicators of abundance with a degree of uncertainty. In this context, and considering various potential approaches, a recovery target representing 40% of the average abundance indices prior to the decline during 1990s seems appropriate. According to this approach which involves the precautionary approach and the surplus production model, the recovery target would be around 5 individuals/hour/net.
Another approach is to involve the COSEWIC designation criteria, i.e. apply a decline in the abundance index greater than 50% over the last 3 generations (15 years), and set a growth

target of at least 50% compared to the 1994 index. This corresponds to an abundance index of at least 5 individuals/hour/net, which is equivalent to the recovery target set by the previous approach.

The techniques used so far to monitor population trends (gillnet surveys) should be reviewed in light of an endangered population. To monitor the population, less harmful methods for the species should be explored. In this context, a conversion of the recovery target in the appropriate unit should be made in order to assess, according to this target, the recovery of the spring cisco population.

Minimum Viable Population (MVP) Size in Order to Maintain Genetic Diversity

A population viability analysis (PVA) applied to Atlantic whitefish (DFO, 2009) and supported by literature, has established a recovery target of 1,275 individuals (average value). This value corresponds to the minimum census population size required to maintain the species' genetic diversity, the effective population size is estimated at 500 individuals. Considering that the census spring cisco population is well below that number, maintaining genetic diversity within the species is of concern.

Trajectory

The absence of key parameter estimates of population dynamics prevents making projections on the development of the population. However, the lack of predictions should not prevent recovery planning, as it is highly dependent on the environment's improvement and restoration.

Habitat Requirements and Residences

The type of thermal variation that occurs in Lac des Écorces is unique to this lake. The phenotypic and ecological differences and reproductive isolation among coregonines would flow directly from a process of natural selection induced by the environment. In this context, and given the endemic nature of spring cisco, all of Lac des Écorces, as a habitat, is essential to survival and recovery of the species.

Knowledge about the habitat use by different life stages is still incomplete but nothing indicates that some parts of the lake are not used. Damage or loss of any and all parts should therefore be avoided.

Adult Habitat

Spring cisco seems to prefer cold and well oxygenated waters (12° C or less). During the summer warming, adults in search of food are present throughout the lake, in the hypolimnion, where the temperature varies from 2.8 to 7.8° C. In the fall, spring cisco can be found throughout the lake, at depths of 12 meters or more. The last physico-chemical survey (2005) showed concentrations of dissolved oxygen suitable for salmonids throughout the year, even in the deep zone. The hypolimnion range evolves according to the depth of the thermocline. This deep layer seems to correspond to the area of growth and feeding of adult cisco.

Spawning Habitat

The spawning habitat of spring cisco requires well-oxygenated water and a temperature below 5°-6° C. In spring, spawners gather in the deep zone of the lake where the temperature is below 6° C. Spring cisco individuals were caught at depths ranging between 20 and 30 meters, over a soft muddy substrate on which eggs are deposited. This adaptation allows the normal hatching of eggs during the summer period with higher temperatures. Preserving habitat quality in the deep zone of the lake is crucial for the survival of spring cisco.

Early Life Stage Habitat

Given the small number of spring cisco collected at the larval stage, it is difficult to describe their ecology. Since the water temperature is already high during hatching in August, special adaptations come into play. Larvae are more tolerant than adults to temperature changes in their environment. However, the lack of catches within the first meter suggests that larvae avoid this section of the water column. The authors therefore advanced the hypothesis of a daily vertical migration.

Residence

The term residence is defined under SARA to mean a "Dwelling place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating". Based on the available information, the concept of residence does not apply to the spring cisco.

Threat Assessment

It is difficult to assess and quantify the impact of threats to habitat on the survival and recovery of spring cisco. However, it is clear that the degradation of the lake shores, discharges of sewage and agricultural waste contribute to the eutrophication phenomenon observed and damage the quality and extent of spring cisco habitat. This enrichment results in a sharp growth of aquatic plants in the bays of Lac des Écorces. Eurasian watermilfoil (*Myriophyllum spicatum*), an invasive exotic species, has now colonized these sites. Cyanobacteria blooms have also been reported. The impact on the survival and recovery of spring cisco is more direct in the case of the introduction of competing and predatory species, especially rainbow smelt. While this threat remains difficult to quantify, it is very significant.

Introduction of Competing and Predatory Species

Over the years, Lac des Écorces (brook trout, walleye) as well as the Kiamika Reservoir (Landlocked atlantic salmon) have been stocked a number of times in an effort to improve the sport fishery. The introduction of competing and predatory species, especially rainbow smelt introduced illegally in the late 1990s in the Kiamika Reservoir and which has now colonized the lake, has brought on changes in the predatory relationships within the fish community. Since the favourite habitat of the rainbow smelt and spring cisco overlap, both at larval and adult stages, competitive and predatory interactions are predictable. Predation by rainbow smelt on the larvae of spring cisco in the deeper parts of Lac des Écorces appears to severely affect the population. The impact of the introduction of rainbow smelt has had on cisco populations, within small water bodies, has been well documented elsewhere in the world. In recent years, the occurrence of largemouth bass has also been noted in Lac des Écorces.

Shoreline Degradation

The level of shoreline development of Lac des Écorces is of some concern. The removal of riparian vegetation by residents is a real threat to habitat. The presence of trees, shrubs and herbaceous plants, in addition to providing a screen against the overheating of the water, can counter the erosion process. This phenomenon has been observed at Lac des Écorces and leads to gradual sedimentation at the bottom of the lake. The shoreline strip also acts as a filter which functions as a cleanser vis-à-vis incoming nutrients and contaminants and acts as a buffer between the terrestrial and aquatic environment. In residential areas, the shoreline vegetation strip also acts as a filter by reducing the intake of nutrients and waste from septic tanks to the lake. The degradation of the lake's shorelines invariably reduces habitat quality and disrupts the entire food web.

Runoff, Leaching and Drainage of Nutrients, Chemicals and Sediment in Agricultural Environments

Several farms (cattle, pig and poultry) are located near the Kiamika River, the main tributary of Lac des Écorces. Adjacent land is also used for forage and grain production. Increased nutrient loading contributes to the proliferation of algae and aquatic plants and accelerates the invasion process of the aquatic environment. Reduced oxygen concentrations, especially in the hypolimnion, could threaten the survival of spring cisco. Soil erosion in agricultural areas increases the supply of sediment, which may have harmful effects on fish, particularly their gills. Sedimentation can also affect the survival of benthic organisms and affect the entire food chain. It can also cause siltation of spawning grounds and reduce the reproductive potential of the species. Pesticides that are found in water, in addition to their individual and cumulative toxicity, may act as endocrine disrupters. They can also affect the swimming activities of fish, their behaviour and reproductive mechanisms.

Wastewater from Neighbouring Municipalities

Until 1995, the municipalities of Lac-des-Écorces and Chute-Saint-Philippe discharged their untreated wastewater into the Kiamika River. Since then, the wastewater has undergone primary or secondary treatment, and is then discharged into the river. Wastewater, in addition to representing a thermal input, increases the amounts of nutrients, contaminants and pathogens in the lake ecosystem. At toxic concentrations, these substances can harm living organisms by impairing or interfering with their biological functions. They can also be lethal.

Climate Change

Global warming has a potential amplifying effect on the eutrophication process. According to most models, the fastest and most marked effects of these changes should be felt in northern latitudes. Boreal forests and wetlands may be the most vulnerable. Environmental monitoring studies from across the Boreal Shield ecozone suggest that dramatic changes to primary productivity, carbon storage, hydrology, and fish habitat have already occurred, and may lead to malfunctioning of Shield communities and ecosystems.

According to available information, a level of importance was given to the threats identified (Table 1). The introduction of competing and predatory species, in particular rainbow smelt, is considered a very significant direct threat. All threats to the quality and range of habitat are also considered very significant and may be critical to the survival and recovery of the species.

Table 1. Level of importance given to primary threats

Threat	Level of importance
Introduction of competing and predatory species	1
Shoreline degradation	2
Runoff, leaching and drainage of nutrients, chemicals and sediments in agricultural environments	2
Wastewater	2
Climate change	3

Mitigation Measures

To increase the likelihood of spring cisco survival and recovery, mitigation measures have been identified for each targeted threat (Table 2). It appears that controlling the rainbow smelt population could help restore the spring cisco. Measures to mitigate threats to the habitat could also promote the survival and recovery of the species.

Table 2. Mitigation measures for targeted threats

Threats	Mitigation measures
Introduction of competing and predatory species	• Prohibit any stocking for sport fishing or other purposes. • Control the rainbow smelt population (directly by massive removals or by limiting access to spawning grounds). • Assess the possibility of increasing rainbow smelt predation (increase the walleye population). • Raise public awareness.
Shoreline degradation	• Apply Quebec's policy on shorelines, littoral zones and floodplains (*Politique de protection des rives, du littoral et des plaines inondables*) within the development plan of regional county municipalities (MRCs). • Raise the awareness of shoreline residents. • Revegetate shorelines. • Restore wetlands.
Runoff, leaching and drainage of nutrients, chemicals and sediments in agricultural environments	• Apply an integrated water management at the watershed level. • Recognize the shoreline conservation measure. • Ensure good agri-environmental practices. • Recognize the absorption capacity of the receiving environment. • Raise the awareness of agricultural producers.
Wastewater	• Comply with government standards in terms of wastewater and water quality. • Improve wastewater treatment systems. • Make sure that the Regulation respecting waste water disposal systems for isolated dwellings is properly applied. • Increase the retention capacity of phosphorus by septic systems. • Raise public awareness.

Measures to Increase Productivity

Measures to increase productivity in the medium term can be considered, but their feasibility will have to be carefully evaluated:

- Implementation of an artificial reproduction plan for spring cisco.
- Stocking of spring cisco in bodies of water with similar conditions as Lac des Écorces.

Sources of Uncertainty

Available data on spring cisco are limited, which prevents conclusions in terms of population abundance. Only a general trend can be found. The absence of key parameter estimates of population dynamics prevents making projections on the development of the spring cisco population. Knowledge about the habitat use by different life stages remains partial. Lack of information on threats prevented a precise quantification of impacts.

CONCLUSION

Many representatives of the *Coregonus* genus are endangered or have disappeared, illustrating the precarious situation of several North American populations. In the case of spring cisco, the trend over the last fifteen years reflects a significant decline in the population. The survival and recovery of spring cisco depends on its sustained production in Lac des Écorces, the only known habitat in Canada for the species. According to current available knowledge and information, the recovery of spring cisco remains uncertain, but possible. The high fecundity rate combined with optimum environmental conditions revealed strong periodic recruitment in some coregonines.

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